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Operator's Manual for the Ballistic Data Acquisition System (BDAS)

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14. ABSTRACT

The U.S. Army Research Laboratory (ARL) purchased hardware and software from National Instruments, Inc., to improve its existing data collection system in support of ballistic testing of military systems. The hardware and software have been configured with a personal computer to create a stand-alone, computer-controlled, data acquisition system with real-time data display. The data acquisition system is called "BDAS," an acronym for ballistic data acquisition system. The first priority was to establish a reliable capability that met ARL's existing and near future needs. ARL is already planning improvements for BDAS: 1) to add the capability to measure accelerometers and strain gauges, and 2) to move the instrumentation into the field to reduce the length of the signal cables. The purpose of this manual is to provide the intended user with a basic understanding of how to set up and use this system, not to document the actual software coding. This report describes how to use the BDAS software to properly configure the data collection channels, to create and calibrate probe files, to use the system to verify data channels and probes before testing, and to acquire and save test data.

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1. Overview

The Survivability/Lethality Analysis Directorate of the U.S. Army Research Laboratory (ARL) purchased hardware and software from National Instruments, Inc., to improve its existing data collection system in support of ballistic testing of military systems. The hardware and software have been configured with an ARL personal computer to create a stand-alone, computer-controlled, data acquisition system with real-time data display. The data acquisition system is tentatively called "BDAS," an acronym for ballistic data acquisition system.

The purpose of this report is to provide the intended users with a basic understanding of how to set up and use this system, not to document the actual software coding. The software was created with a goal of being flexible enough that the user could configure the system to collect data in a variety of situations strictly by using the front user's panel.

It must be noted that this is ARL's first attempt at developing an instrumentation system around the new hardware and software. The first priority was to establish a reliable capability that met ARL's existing and near future needs. There is certainly room for improvement and growth in capabilities and complexities. ARL is already planning improvements for BDAS: 1) to add the capability to measure accelerometers and strain gauges, and 2) to move the instrumentation into the field to reduce the length of the signal cable.

1.1 BDAS Instrumentation

ARL purchased a modular instrumentation system from National Instruments, based on a peripheral component interconnection (PCI) eXtensions for Instrumentation (PXI) 1011 chassis (see Figure 1). The PXI combines a high-speed PCI bus with integrated timing and triggering capabilities. The PXI 1011 chassis is modular, allowing the user to customize the plug-in modules to meet his or her particular requirements. The 1011 has four slots for compact PCI modules and eight slots for Signal Conditioning eXtensions for Instrumentation (SCXI) modules. ARL's system currently uses the PXI 8170 controller, PXI 6052E multi-function input/output and PXI 8211 ethernet compact PCI modules. Four SCXI modules were installed: the SCXI 1100 and SCXI 1102 analog input modules, the SCXI 1126 frequency input modules, and the SCXI 1162HV digital input module.

The PXI hardware is controlled via custom software developed specifically to meet ARL's data collection requirements. ARL is using the latest version (6.1) of National Instruments' LabVIEW[1] software. Microcraft Corporation was contracted to provide a basic software architecture to operate the PXI system. ARL has made significant improvements in the basic code to improve existing capabilities. Many of the improvements were based on user feedback

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[1]LabVIEW™ is a trademark of National Instruments, Inc.

and on efforts to streamline the setup and execution of the software. With LabVIEW, the developer builds a graphical program called a virtual instrument (vi) rather than writing a text-based code. The user interfaces with the code through a front panel screen (see Figure 2) that allows the user to define input and variables and displays output resulting from the operation of the code. A graphical block diagram is constructed by the user connecting function icons with wires that represent data (or information) flow (see Figure 3).
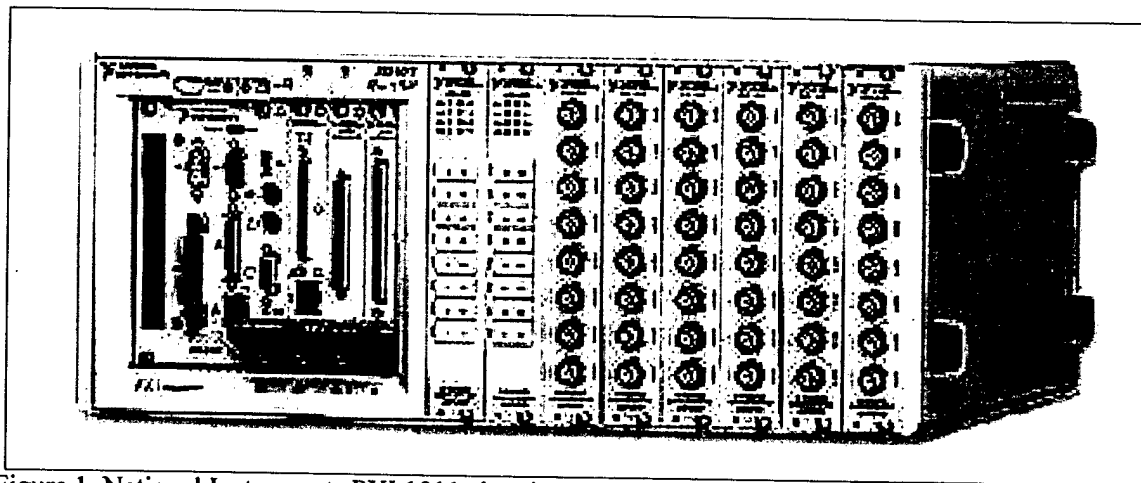
Figure 1. National Instruments PXI 1011 chassis.
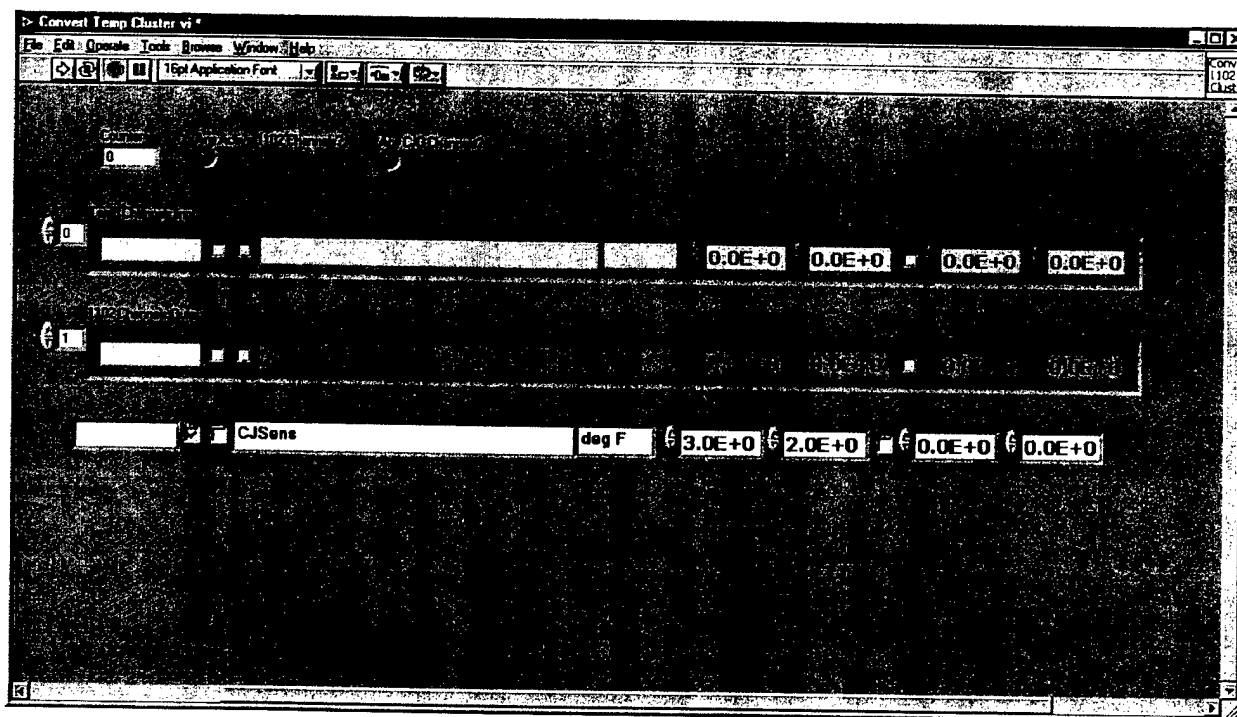
Figure 2. LabVIEW front panel.
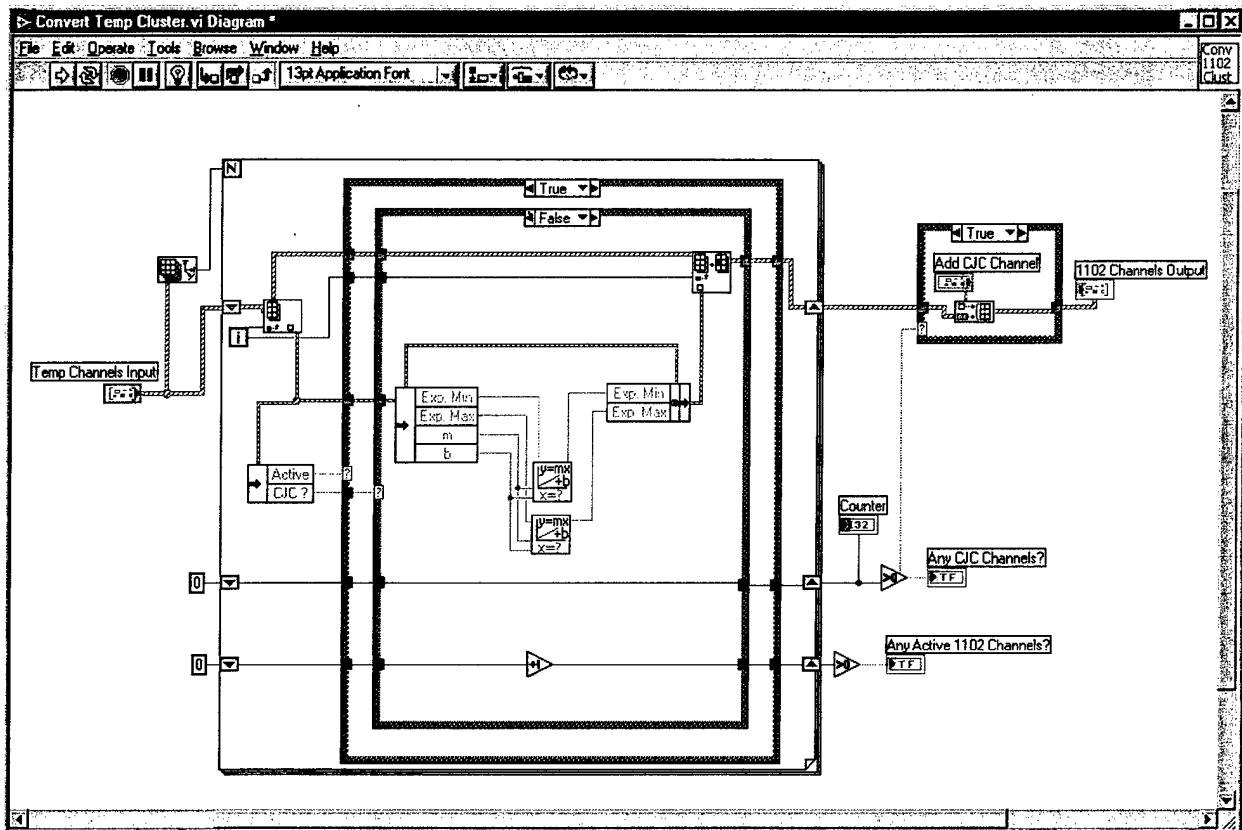
Figure 3. LabVIEW diagram.

1.2 BDAS Software Overview

The user executes the BDAS software by launching the MAIN.VI routine (see Figure 4). From the MAIN.VI front panel, all subroutines/features can be launched. The user's menu is the horizontal bar of buttons across the panel top. The setup button enters the test point configuration subroutine. Each data point is defined with a test point description, measurement probe, expected data range, alarm activation, and trip levels. The "calibration" button enters the probe definition and calibration routine. Within this subroutine, a new probe can be entered into the probe listing, and new calibration factors can be entered for existing probes. Executing the monitor button does not launch a new front panel but activates the PXI hardware and begins to acquire and display the data on each channel. This routine is intended as a hardware verification capability and does not save any of the data. The sampling rates are slowed, and the raw un-scaled data are displayed with the scaled data to help in the verification process. The "record" button launches the data collection routine. A formal display is launched with separate indicators for each data channel. Within this routine, the alarms are activated to warn if levels exceed or fall below the thresholds defined in the setup menu. The "stop" button halts either the monitoring or recording subroutines. The "exit" button halts the entire software execution. The user can plot and print current or previous data files by selecting the "graph data file" button.
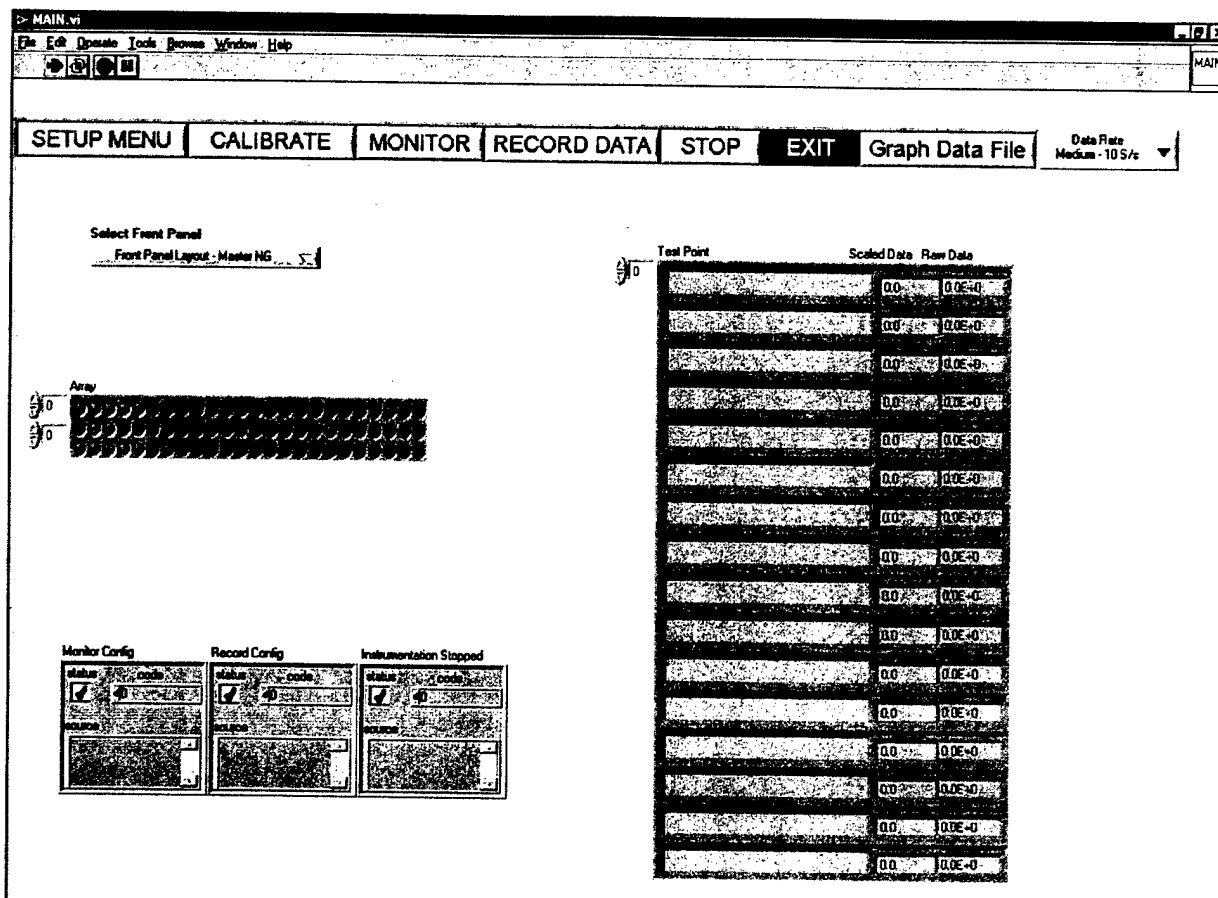
Figure 4. Main menu.

2. Detailed Explanation of BDAS Software

An important aspect of the BDAS software is the organization of the computer files. There will always be a specific directory for each of the following: test configuration files, probe calibration files, front panel displays, saved data files, and executable software. A primary goal in developing the BDAS software is the organization of the computer files and the prevention of multiple copies of software files. Within BDAS, default directories are "hard wired" into the code, thus preventing specific types of files from being saved in alternate locations. While this may appear to limit user flexibility, it is intended to prevent multiple calibration files for one probe or similar type conflicts from occurring.

2.1 Main Menu

MAIN.VI is the primary software routine that serves as the primary user interface and the launch point for the major subroutines shown in Figure 4. The horizontal menu bar at the top of the front panel allows the user to select major subroutines. The green menu button at the top right allows

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the user to choose three possible data acquisition speeds: 1 sample per second (S/s), 10 S/s, and 100 S/s. These sample rates are used during the record data portion of the code. The actual data sampling rate of the PXI system is a factor of ten higher. Each data channel is sampled ten times and then averaged to report a single data point. The averaging is effective in the reduction of signal noise levels, particularly for low amplitude signals. The "select front panel" menu button allows the user to use a pre-defined front panel window to display the data during the actual test. The front panel is a customized display, created by the user, which presents the acquired data in real time. Any combination of dials, gauges, switches, lights, meters, and digital displays is available to the user to present the data. The desired front panel must be chosen before the "record data" button is selected from the main menu. The series of small, light-emitting diode (LED)-style, green lights indicates the active channels that are configured to acquire data. The top row represents the SCXI 1100 channels, the middle row represents the SCXI 1126 channels, and the bottom row represents the SCXI 1102 channels. The number of lit green LEDs indicates the number of channels that will be recorded during data collection. The data channel list in the middle right of the panel provides a quick channel monitoring capability. It is a very simple, compact display of the raw and scaled data. The intent was to give the operators a quick monitoring capability without recording the data or possibly creating a new front panel. This feature would typically be used during instrumentation/probe verification. In the bottom left corner of the MAIN.VI front panel, three error display boxes show the operating status of the software. The left error box displays the instrumentation status after the channel configuration has been established but before the collection of data in the monitor data mode. The middle error box displays the same information for the record data mode. The right error box displays system status after the monitor mode or the record data mode has been completed. Note that there are two classes of system status errors: fatal and non-fatal. Fatal errors typically result in aborted data collection. The software may be need to be closed and re-launched to clear the errors. Non-fatal errors are often caused when configuration parameters are sent that are not within the instrumentation's range. The instrumentation will then revert to default parameters and issue the non-fatal error. Non-fatal errors should not be ignored. These errors are telling the operator that something is not properly configured as planned and the default parameters might not meet the operator's requirements.

2.2 Setup Menu

The setup menu defines the data channels, test points, probes, anticipated signal levels, and alarm levels for a particular test configuration (see Figure 5). The BDAS software uses these input values to program the PXI/SCXI measurement system before the data signals are measured. There is a menu bar across the top with four buttons. "Load" will allow the user to recall previous test configurations that have been previously saved. "Save" will create a new setup file or overwrite the existing configuration. "Clear" will remove all user input and begin again with an empty configuration. "Done" closes the setup menu and returns the user to the main menu. "Done" does not automatically save the current configuration information; the user must select

the "save" option before exiting. Forgetting to save the setup before selecting "done" will not erase the current setup configuration. The new configuration will be used to acquire and save the data. Once the main menu is exited, the changes will be lost.

The green portion of the screen has four tabs similar to file folder tabs. Each tab is a specific SCXI card. The fourth tab is shaded since BDAS software is not currently configured to operate that card. Each tab page has an identical set of input parameters that are used to configure each data channel. Each row represents a sequential channel, starting with channel 0. The 1100 and 1102 cards have 32 channels, and the 1126 card has eight.
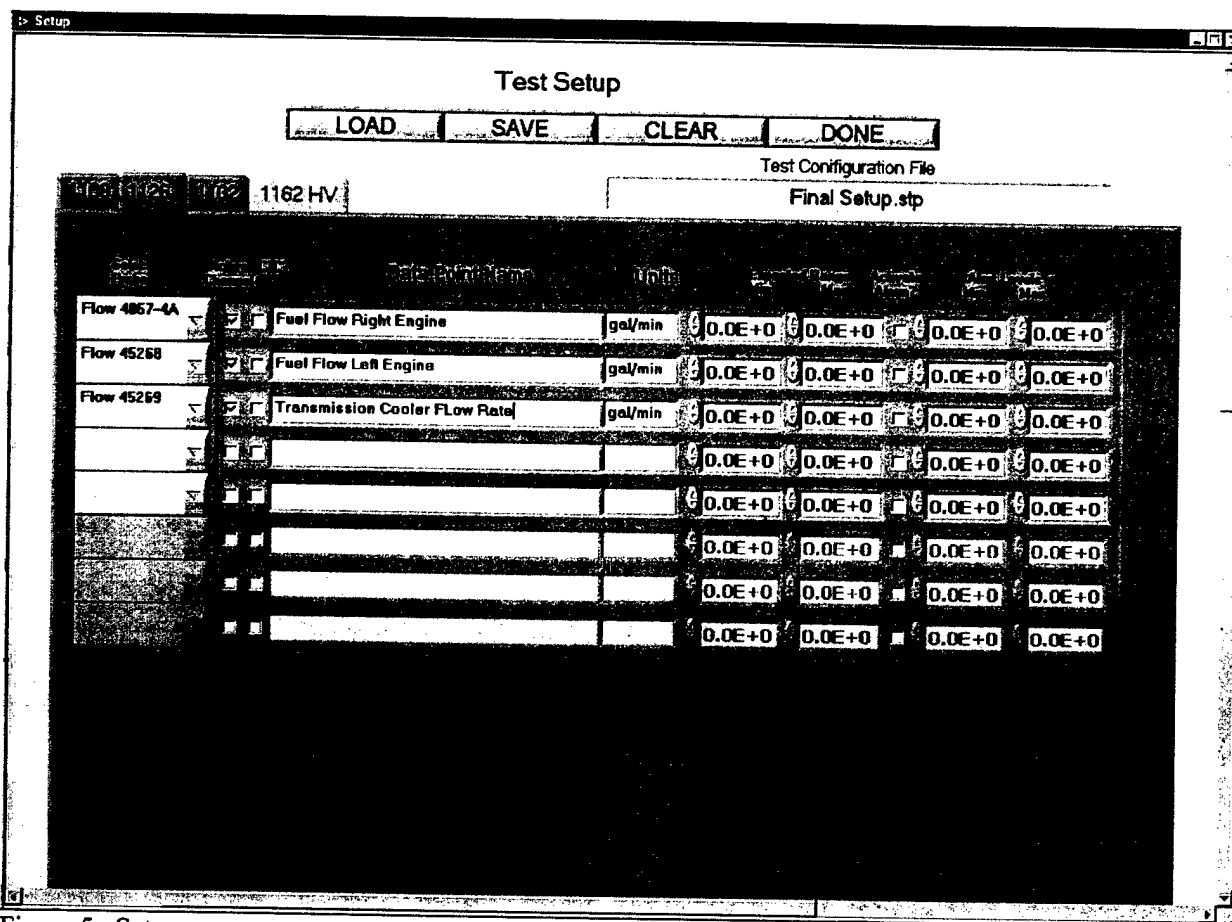
Figure 5. Setup menu.

We create the "select probe" list by loading all available probes from the probe directory. The specific probe displayed from that list is the current probe identified for that particular data channel. The "active" window is a checkbox to turn on that particular data channel. Despite all the other windows being filled with information, if this box is not checked, data will not be acquired for that particular channel. At the moment, it is required that the active data channels be in a group, starting at the top of the list. From a performance perspective, it is much faster to download a group of sequential data channels than to ask for each data channel separately. Therefore, the software is configured strictly to capture data as one sequential group per SCXI

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card, whether that group consists of 1 or 32 channels. If a gap in the data channels is unavoidable, the user should activate those channels within the gap, enter "unused channel" as the data point name, and select the "zero probe". The "CJC?" window is a checkbox to turn on the cold junction compensation for that particular data channel. CJC is used when one is collecting temperature data with a thermocouple directly connected to the instrumentation. While the "data point name" may be self-explanatory, it is important to enter a good test point descriptor. This test point description will be used throughout the data collection and saving process, and there will not be an opportunity to change it after you exit the setup menu. The "units" window is a descriptor loaded from the probe file. These are the units in which the scaled data will be displayed and saved. The "expected range" windows are the anticipated range in which the field measurement is expected to occur for that particular test point. It is important to enter a reasonable estimate since the BDAS software uses this information to configure the settings for each channel. The minimum and maximum are the expected field measurement levels (i.e., pounds per square inch, degrees Fahrenheit, gallons, etc.), not the sensor output levels. The "activate alarm?" checkbox turns on the alarm capability for that particular channel. Alarms are used in the user's front panel during data collection to warn the user if a particular test point is too high or too low. The "alert levels" are completed in a manner similar to the expected range windows.

The setup menu is very important since this configuration information flows through the rest of the BDAS software. Any channel that is activated will be saved, regardless if the data are ever displayed by the user in other BDAS menus. After one exits the setup menu, the activated data channels from each SCXI card are used to create a single data channel list. The ordering of this list never changes throughout the remaining BDAS routines.

2.3   Calibration Menu

The "calibrate" button on the main menu launches BDAS' probe calibration routine (see Figure 6). From the probe calibration menu, the user can create a new probe file, revise calibration factors, review old calibration curves to look for significant changes, or use the PXI instrumentation to determine new calibration factors. Aside from thermocouples, all other probe calibrations are based on a linear amplification with a constant offset. Mathematically, this is represented as

$$y = mx + b$$

in which y is the field measurement (pounds per square inch, degrees Fahrenheit)
        x is the probe output (volts, hertz)
        m is the scaling factor
        b is the offset

The calibration factors for thermocouples are built into the LabVIEW software and are based on National Institute of Science and Technology polynomial values. The top center group of control buttons is the menu for this subroutine; the top left dialog box identifies the probe name; and the list of probe data displays the current data associated with that probe. The user can change the

probe data by overwriting the existing information. The graph in the bottom center of the panel displays the last five calibration curves saved for that particular probe. Superimposing previous calibration curves will allow the user to watch for sudden or significant changes in a probe's response, which could indicate possible damage to the probe. The calibration subroutine automatically tracks the number of calibrations and sequentially numbers and displays the most recent calibration in the "calibration version" text box.
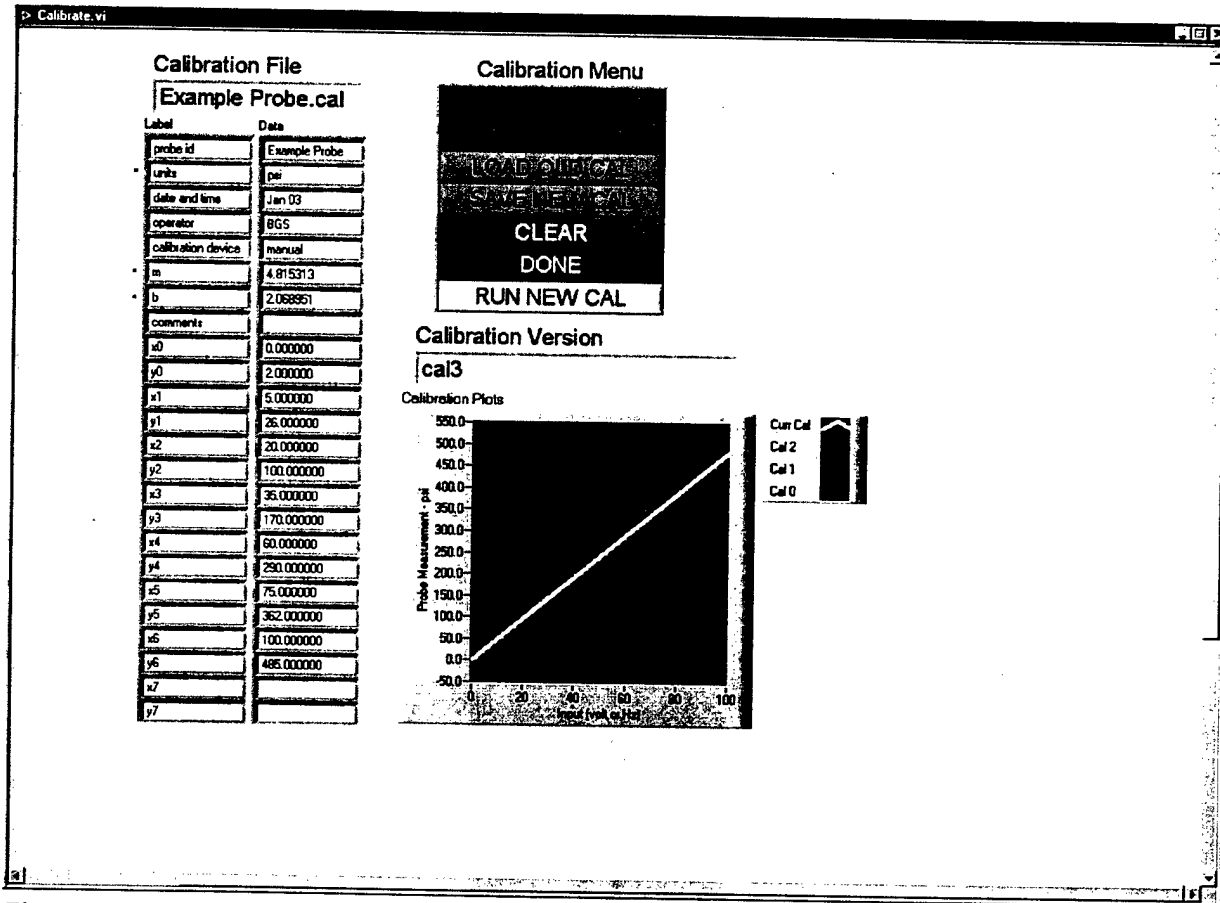
Figure 6. Calibration menu.

The buttons on the calibration menu are fairly self explanatory. "Load sensor" allows the user to select an existing probe from the probe directory. "Save new sensor" prompts the user to create a new probe file using the information currently in the probe data display. "Load old cal" removes any changes made by the user and reloads the probe data from the file. "Save new cal" saves the current probe information as the current calibration. "Clear" removes all data and probe information from the user panel. "Done" exits this calibration menu and returns the user to the setup menu. Returning to the setup menu ensures that any revised calibration data are automatically loaded into the configuration files for the data channels. Simply selecting "done" in the setup menu returns the user to the main menu.

The last button in the calibration menu is "run new calibration." This launches a subroutine that allows the user to use the PXI instrumentation and BDAS software to create new calibration data (see Figure 7). The "new calibration" subroutine allows the user to enter specific measurement points (i.e., 50 psi equals 1 V for a pressure sensor) to be used to determine the overall probe calibration curve. As in the calibration menu, the graph displays the five most recent calibration curves. This graph also plots the specific data points, represented by the yellow X's, which will be used to calculate the new calibration curve. On the left side of the front panel, there is a "SCXI card" menu ring that allows the user to select one of the three SCXI cards or a manual option. Below the SCXI card menu ring is a "channel" selection which identifies the specific data channel from the selected SCXI card to which the probe to be calibrated is connected. This selection is ignored in the manual option for the card selection. The user enters the external measurement (i.e., 50 psi) into the "field measurement" data box and then selects "enter calibration point" to save the probe's response from the SCXI card. In the manual mode, the user also enters the probe's response (i.e., volts) and then enters the external measurement into the "field measurement" window. the operator must enter at least two calibration data points for the BDAS software to calculate the calibration curve. As more calibration data points are added, the BDAS software continuously recalculates the calibration factors based on all the entered data. If an erroneous data point is entered, "remove last data point" can be selected. Continuing to select remove last data point will delete additional points in reverse order from which they were entered. Once the user has completed revising the probe calibration data, selecting "exit" will return to the main probe calibration panel. The user must then select "save new cal" or "save new sensor" for the revised calibration curves to be saved and used.
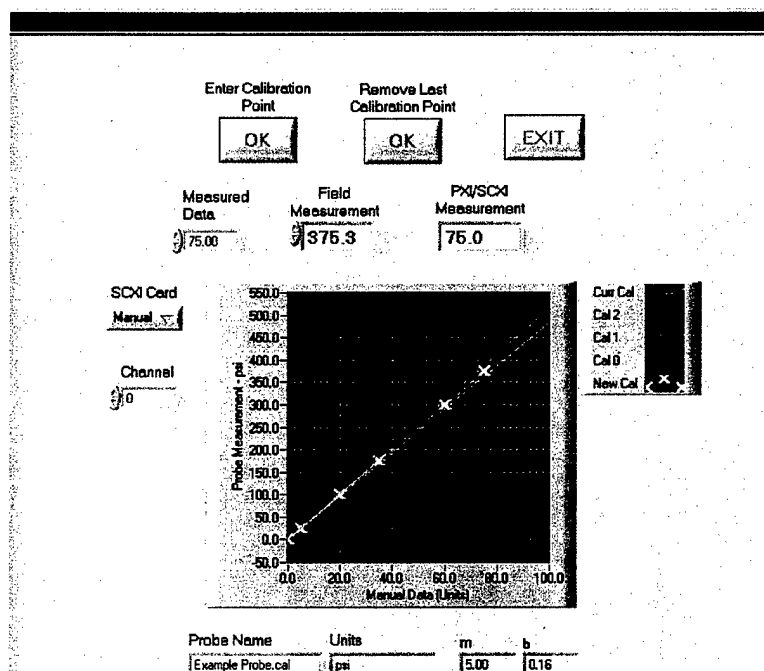

Figure 7. New calibration menu.

2.4 Monitor Data

Selecting the "monitor" button from the main (see Figure 1) user panels launches the PXI instrumentation into the data collection mode. The system is configured according to the setup menu, so the data channels need to be properly defined and activated. The monitor mode is intended to be used as a system verification tool to be used before actual data collection. The data scan rates are slow and no data are being saved. Unlike the previous subroutines, launching the monitor subroutine does not launch a new user's panel. Data from the PXI system will begin to be displayed on the "monitor data channels" display in the center right of the main menu panel. The display is actually an array of information which includes the test point description (from the setup menu), and the scaled and raw data. The digital toggle control at the top left will allow the user to scroll through data channels to view data channels that might otherwise be off the screen. The intended use of the monitor capability is to aid in instrumentation setup, probe installation and operational verification of the test system. This capability could be run all day without taxing the instrumentation or computer system. Selecting the "stop" button from the main menu halts the monitoring subroutine and returns the user to the main menu.

2.5 Record Data

The "record data" button on the front panel launches the main data collection routine. The front panel layout chosen by the user from the "select front panel" menu option is launched to display the data in a more user-friendly manner. Immediately upon entering the front panel, the operator will be prompted to enter a file name for the saved data. The default directory is "practice data". The operator is encouraged to select another directory within the "all ballistic data" directory if this is an actual data event. BDAS software automatically detects the directory in which the data are being saved. Once the data have been collected and saved and the operator exits the "record data" menu, files that were saved to non-practice data directories will be automatically copied in the "backup ballistic data files" directory. Once entered, the file name cannot be changed unless the user exits and then re-enters this subroutine. Once the file name has been entered, the data are not automatically recorded in the file. The software begins a data monitor mode similar to the main menu monitoring. The yellow monitor light is turned on, and the data are shown on the front panel displays. Selecting the "record data" button begins the actual saving of the incoming data to the file. The user can start and stop the saving of the data as the test conditions require. The new data are merely appended to the bottom of the existing data file. Since time is automatically collected for each data point entry, the user will be alerted to the break in recording by the gap in the time data.

The front panel layout is customized before the test by the user (see Figure 8). The user selects from a variety of optional displays to best present the collected data. A detailed explanation of how to customize and save user panels is discussed in Section 3 of this report. An important note is that even though a particular piece of data is not displayed, if configured in the setup menu, it is still being acquired and saved with the other data channels. In the setup menu, the user had the

option of activating an individual alarm for each channel. The user also defined a minimum and maximum threshold for that particular channel. The channels that are being displayed with a green display background have alarms activated, and the data are currently within the "min/max" thresholds. If the data fall below the minimum alarm threshold, the display background will turn yellow and an audible alarm will sound. If the data exceed the maximum threshold, the display turns red. Data channel displays that have a gray background do not have an activated alarm. On the right side of the front user's panel are two switches used to control the audible alarm. The top switch turns the audible alarm off. The gauges will still change color to warn the operator that the data have exceeded the alarm levels. The second switch temporarily activates the alarm just to assure the operator that the audible alarm is working.
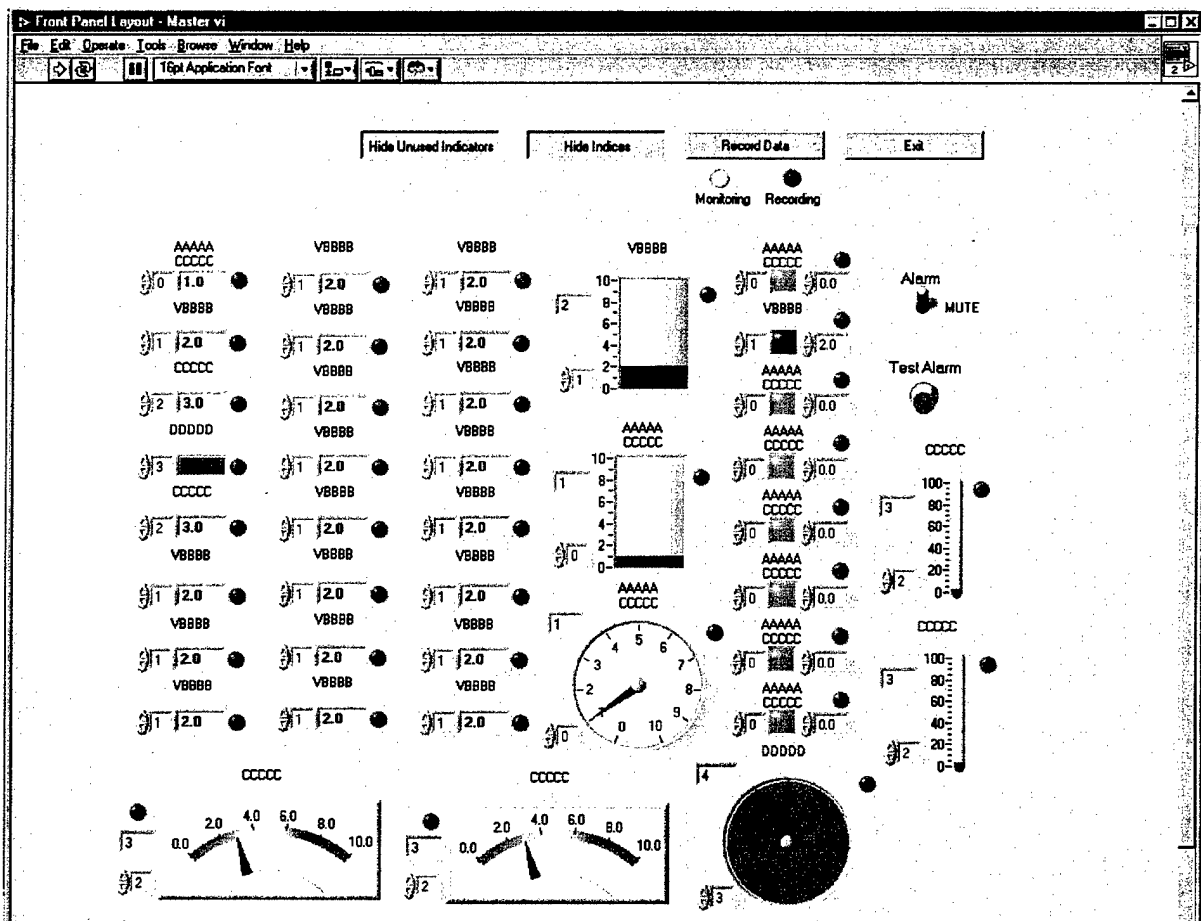
Figure 8. BDAS front panel with display alarms.

2.6 Graph Data File

The "graph data file" button is situated at the top right of the main menu buttons. Selecting this button replaces the normal main menu panel with a series of plots, controls, and displays. This feature automatically prompts the user to select an existing file. This does not have to be the most recently saved file; any file saved in the BDAS data format can be read. The files can take a

long time to load into the software. Some files can be 4,000 data points per channel and 25 channels per test event. Once the files are loaded, the user can quickly go from test point to test point. The "select data channel" allows the user to select from a list of available test points to be plotted. The "select trigger" channel plots the PXI trigger channel in red. The trigger channel is typically a short spike, which allows the user to identify where in the time scale the ballistic shot took place. The maximum, minimum, and mean are quick indicators of the plotted data. The two indicators over the plot area list the file name and the test date stored in the data file. The "print" button will print the plot and indicators with the default printer setup for the host computer.
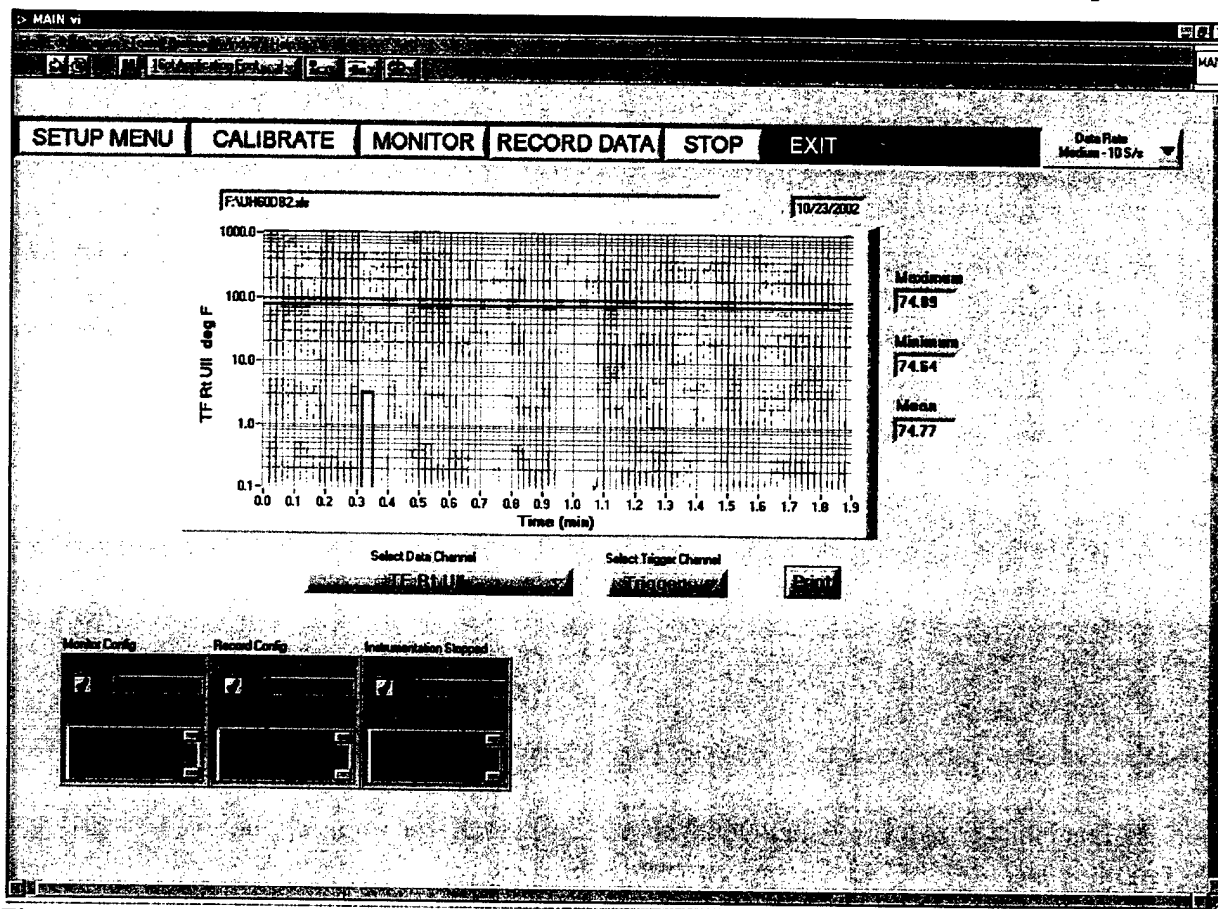

Figure 9. Graph data front panel.

3. Operator's Guide

3.1 How to Launch BDAS

The main executable file is MAIN.vi. Double clicking on the file will automatically load and launch the BDAS software and subroutines. The path is c:\Ballistic Data Acquisition System\MAIN.vi. MAIN.vi automatically starts in the run mode. Selecting the "exit" button is

the preferred method to stop the software. MAIN.vi can be restarted with the LabVIEW run button.

3.2 How to Set Up the Instrumentation for a New Test

From the running MAIN.vi, select the "setup" button. This launches the setup menu. The screen appears as four file folders, one dimmed and the others lit. Each one of these folders represents one of the SCXI cards and is labeled with the card's model number. Each folder has a list of empty text blocks, with each row representing a channel on that card. The rows are sequential channels, starting at channel 0. The user must select the test probe, activate the channel by selecting the check box, select CJC if the probe is a thermocouple, enter an appropriate test point description, and enter the expected minimum and maximum range of the field data. The software will convert the field data range to the input signal levels for the instrumentation based on the selected probe's calibration curve. This conversion occurs after user exits the setup subroutine, so there is no concern whether the probe or the data range is entered first. The test point description should be complete and accurate. This description will be used throughout the BDAS program and saved with the data. There will not be an opportunity to change the description later. If the user wants an alarm connected with that particular data channel, the check box must be selected and the alarm ranges entered. Similar to the data ranges, field data levels will be used and BDAS will convert them to instrumentation input levels. Once the setup file is configured as desired, the user can store the setup configuration by selecting the "save" button. The operator can use the setup configuration without saving it by selecting "done". Until the MAIN.vi is closed, the setup information will remain in memory. The operator can return and save the setup file after exiting the setup menu. All setup files are maintained in the directory path c:\Ballistic Data Acquisition System\Setup\.

3.3 How to Load/Modify an Existing Setup File

From the main menu, the user selects the "setup" button. The setup menu will be empty if setup has not been run; otherwise, it will have a previous configuration loaded. Selecting the "load" button and choosing a configuration file will overwrite any existing information in the setup menu. The user can save the modified setup configuration as a new file name or can overwrite the current file by selecting the "save" button. As with creating a new setup configuration, the user can use changes but not save them by selecting "done" without saving the configuration.

3.4 How to Create a New Probe

From the main menu, the user selects the "calibrate" button. The calibration menu panel will replace the main menu panel. The left side of the screen has an empty probe calibration file. The items with a * beside the text box (see Figure 6) must be completed for the probe to work properly. It is recommended that as much information as possible be entered into the first eight description text boxes. If the calibration factor (m & b) is unknown, the user should follow the instructions elsewhere in this report to calibrate a probe using field data. The only special types

of probes that are not calibrated with a linear calibration curve are thermocouples. BDAS uses special National Instruments software to calibrate for thermocouples. To create a thermocouple probe, the user must enter the numbered type of thermocouple in the "m" value; "b" should be 0. Table 1 lists the thermocouple calibration values.

Table 1. Calibration values for specific types of thermocouples

Thermocouple Type	"m" Calibration Value
B	0
E	1
J	2
K	3
R	4
S	5
T	6
N	7

Select the "save new sensor" button to create a new probe file. All probes are saved in the c:\Ballistic Data Acquisition System\Calibration Data\ directory. This is the only directory read by the setup menu, so probes saved in other directories will not be found by the BDAS software.

3.5 How to Calibrate a Probe With Known Calibration Factors

The user selects the "calibrate" button from the main menu. S/he then loads an existing probe by selecting "load sensor" or creates a new probe as described before. The user enters the new values for "m" and "b" and ensures that the units are still correct. For an existing probe, the user selects "save new cal," and selects "save new sensor" for a new probe. When s/he exits the calibration menu, the BDAS software automatically goes to the setup menu to enter any new calibration data into the setup configuration. The user selects "done" from the setup menu to return to the main menu panel.

3.6 How to Calibrate a Probe Based on Field Data

At least two data points are required; the software will use all data points entered to create a calibration curve. The user selects the "calibrate" button from the main menu. S/he then loads an existing probe or creates a new probe, as described before. The user selects the "run new cal" button from the calibration menu. The probe calibration routine panel will replace the calibration menu panel. The graph displays the last five calibration curves listed for the probe. The previous calibrations are graphed to help the user watch for sudden changes in a probe, signifying probe damage or instrumentation error. The user selects "manual" from the SCXI card choices. This will allow him or her to enter the external measurement in the "measured field data" window and the probe's response (volts, hertz, etc.) in the "probe measurement response" window. The BDAS software is programmed to work with the base units for a probe's response (i.e., data are entered in volts). The measured field data values need to be in the same units as defined in the probe description. Once the correct measured field data and probe measurement response values

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have been entered, the user selects the "enter calibration point" button. The graph will immediately display a yellow "X" showing how the calibration point compares with previous calibrations. Once a second point is added, BDAS begins to draw the calibration curve. As each additional calibration point is added, the BDAS software continuously re-calculates the calibration curves, based on all the available data. Below the graphs are displays of the calculated calibration curve factors, "m" and "b". NaN (not a number) is listed as the default to prevent incomplete calibration efforts from resulting in erroneous calibration factors. The user can delete incorrect calibration points by selecting the "remove last calibration point" button. Once all the calibration points have been entered, the user selects the "exit" button to return to the main calibration menu. The new "m" and "b" calibration factors and the calibration data points will be added to the probe description window. The user must select "save new cal" for the new calibration curves to be saved. Selecting "done" without saving the calibration will lose the new calibration curves. When the user exits the calibration menu, the BDAS software automatically goes to the setup menu to enter any new calibration data into the setup configuration. The user selects "done" from the setup menu to return to the main menu panel.

3.7 How to Calibrate a Probe With the PXI Instrumentation

The procedures are similar to those describe for calibration with field data. The user selects the "run new cal" button from the calibration menu. The probe calibration routine panel will replace the calibration menu panel. The graph displays the last five calibration curves listed for the probe. The previous calibrations are graphed to help the user detect sudden changes in a probe which signify probe damage or instrumentation error. The user selects the SCXI card from the SCXI card choices and then selects the appropriate channel for that particular card. S/he connects the probe to the known external signal, and the PXI instrumentation automatically measures the probe's response. The user enters the external field data (pounds per square inch, gallons per minute, etc.), remembering that the field data measurements need to be in the same units as defined in the probe description. Once the correct field data value has been entered, the user selects the "enter calibration point" button. The PXI instrumentation is programmed to revise several times a second and will continuously monitor the probe response. An error message window will appear if there are difficulties in communicating with the PXI system. The graph will immediately display a yellow "X" showing how the calibration point compares with previous calibrations. Once a second point is added, BDAS begins to draw the calibration curve. As each additional calibration point is added, the BDAS software continuously re-calculates the calibration curves, based on all the available data. Below the graphs are displays of the calculated calibration curve factors, "m" and "b". NaN (not a number) is listed as the default to prevent incomplete calibration efforts from resulting in erroneous calibration factors. The user can delete incorrect calibration points by selecting the "remove last calibration point" button. Once all the calibration points have been entered, the user selects the "exit" button to return to the main calibration menu. The new "m" and "b" calibration factors and the calibration data points will be added to the probe description window. The user must select "save new cal" for

the new calibration curves to be saved. Selecting "done" without saving the calibration will lose the new calibration curves. When the user exits the calibration menu, the BDAS software automatically goes to the setup menu to enter any new calibration data into the setup configuration. The user selects "done" from the setup menu to return to the main menu panel.

3.8 How to Know Whether the BDAS Software Has Loaded the Setup Configuration Data

The main menu has a four-row LED display. Each row represents an SCXI card, and each lit LED represents an active channel on that card. The ordering of the rows corresponds to the order of the SCXI cards in the setup menu: 1100, 1126, 1102, and 1162HV. If no LEDs are lit, the BDAS software is not prepared to collect data from the PXI instrumentation. The user should select the "setup" button from the main menu to load the data channel configuration information.

3.9 How to Build a Customized Front Panel

Building a front panel is probably the most challenging portion of the BDAS software. The user needs to have a basic understanding of the setup and main menu subroutines before building a front panel. The easiest method involves a two-step process. The first step has the user create an appropriate setup file and run the "record data" routine to configure the front panel with the correct number of indicators and their matching data channels. The second step halts the code operation, and the user arranges the selected indicators on the front panel. Remember, all the incoming data channels do not have to be displayed to be saved.

To start creating a custom front panel, the user should launch the MAIN.vi software. If an appropriate setup configuration file does not exist, one needs to be created. Once the correct setup configuration has been loaded, the user needs to choose a front panel from the "select front panel" menu ring. There are two master files to choose from to build a custom front panel. The "front panel layout – master" has a combination of 24 numerical indicators, eight lights, and eight gauge-type displays. The "front panel layout – master NG" has a combination of 32 numerical indicators and eight lights. For both panels, the number of displays can easily be reduced but not increased beyond the original number. The user determines if the gauges are desired for the front panel and selects the appropriate master file. Once the front panel has been selected, s/he pushes the "record data" button. The front panel will appear and the user will be prompted to enter a file name. The user uses the default name and saves the file in the "practice data" directory. While the BDAS software is running, the user should use the blue LED buttons to hide the display indicators not needed for the final front panel. Once the quantity and type of indicators match the desire front panel configuration, the user should use the index control with each indicator to match the desired data channel with the indicator. As the index control is changed, the title of the indicator will change. The titles are from the data point name in the setup file. At this point, all that is important is that the correct number and type of indicators are selected and that the appropriate data channel is chosen for each indicator. Once the data channels have been assigned to each indicator, the threshold needs to be defined for each light indicator used on the front panel. The lights are used to signify that some component is

functional (i.e., a fuel pump is on) or that a value has exceeded a certain level (fuel tank is now 100 gallons full). The user needs to enter the threshold value based on the field data units (pounds per square inch, gallons, etc.) The user selects "hide unused indicators" and "hide indices" to remove the blue LED buttons and the index controls. Once this is completed, the user selects the "stop" and then "exit" buttons from the front panel.

The new front panel can be selected from "open applications" in the window's taskbar at the bottom of the screen. From the "operate" menu of the LabVIEW toolbar, the user ensures (and changes if necessary) that the front panel is in "edit" mode. The user should select the "make current values default" menu choice from LabVIEW's operate menu. This should be done periodically as the new front panel is created and must be done before the completed front panel is saved. To avoid corrupting the master front panel files, the new front panel should be saved to a new file name with the "file save as" command. This file will now be listed in the main menu's "select front panel" list. All front panels are saved in c:\Ballistic Data Acquisition System\Front Panels\ directory. The user should now drag and drop the indicators into the desired position on the front panel. By right clicking with the mouse on the front panel background, the user can add lines, frames, or shaded boxes to help group the indicators. Toggling through the LabVIEW controls with the "tab" key allows the user to choose a paintbrush tool. Clicking on the each display's title and changing its color can further help the user group the indicator displays. By right clicking on the gauges and choosing the "replace" command, the user can replace one style of gauge with another. A gauge cannot be changed into a number display or vice versa because of incompatibilities in the indicators' properties.

Once the data channels have been assigned to each indicator, the threshold needs to be defined for each light indicator used on the front panel. The lights are used to signify that something has turned on (fuel pump is on) or that a value has exceeded a certain level (fuel tank is now 100 gallons full). The user needs to enter the threshold value based on the field data units (pounds per square inch, gallons, etc.). Once the thresholds have been entered and the indicators matched with the data channels, the user should select the "hide indices" button to remove the index and threshold control windows. At this point, the front panel is completed and should represent the intended finished product. The user can select the "exit" button and return to the main menu panel. The user selects the "exit" button on the main menu to halt all LabVIEW execution. When the user minimizes the main menu window, the new front panel should remain on the computer's desktop. The front panel must be saved to keep the current configuration. The new panel will load exactly in the saved configuration when it is loaded by the main menu.

3.10 How to Save Data With BDAS

Saving data is straightforward with the BDAS software. The user needs to launch the MAIN.vi, configure the data channels with the setup menu, and identify which front panel to use to display the data. At the top left corner of the main menu is a green button that lists the possible data collection rates. Typically, 1 S/s or 10 S/s is chosen. The BDAS system actually acquires the

data ten times faster and then averages the ten data points to a single data point to reduce the effects of signal noise. The user should then select the "record data" button, and the front panel will load. The user will be prompted to enter a file name. The file should be saved somewhere within one of the c:\All Ballistic Data\ subdirectories. Aside from files written to the "practice data" directory, the BDAS software automatically makes a copy of any file saved. The secondary file is written to the c:\Backup Ballistic Data Files. When the front panel is initially opened, data are not being saved even though they are being sent to the display indicators. The yellow light labeled "monitoring" is turned on. A new file has been created and the test point header information has been written. The user must select the "record data" from the front panel to begin saving data. The monitoring light is turned off and the green "recording" light is turned on. The idea is to have the BDAS software running in a monitor mode and start saving data immediately before the test. Saving the data can be stopped and started as needed. Once the "exit" button is selected on the front panel, the file is closed and additional data cannot be appended to the file. The BDAS software saves the time with each data point, so a break in the data collection can be determined by an examination of the time data.

3.11 How to Review, Graph, and Print Data Files

BDAS will allow the user to view and print specific test points from the data files. The user must select the "graph data file" from the main menu. The graph and controls automatically replace the existing displays. The user will be prompted to select a file; any file that has been saved in the BDAS file format can be plotted. The "select data channel" button lists the saved data channels available to plot. "Select trigger channels" plots the trigger channel in red with the selected test point. The trigger is typically a spike that allows the user to identify the location of the ballistic shot within the time sequence. The data files can take several minutes to load, and they can have 30 data channels and 4,000 data points per channel. Once the file is loaded, all data channels have been loaded and switching channels.is fast. The y axis labeling is automatically revised, based on the information in the data file. This is one more reason for the user to enter good test point descriptions when creating the setup configuration files. The user can print a graph with the "print" button. BDAS will plot the graph, file name, file date, and min/max/mean indicators to the default printer. To choose a different printer, the user must select the printer from the "page setup" menu in the LabVIEW file controls.